EARLY JURASSIC TEREBRATULIDE BRACHIOPODS FROM ZEALANDIA

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Abstract. Terebratulides, a minor group in New Zealand and New Caledonian Triassic faunas, become second in prominence only to rhynchonellides in the Jurassic. In this study, a total of seven genera and twelve species are recognised and eight new species are described.

Lobothyris simesi n. sp. is present throughout the Sinemurian to middle Toarcian. Loboidothyris fordyci n. sp. is common in the late Sinemurian to Pliensbachian of the Hokonui Hills, and a few specimens are recorded from scattered Pliensbachian-Toarcian localities elsewhere. Zeilleria spiculata MacFarlan and Campbell is found in a narrow zone along the Triassic-Jurassic boundary in the Hokonui Hills. Z. terezaeae n. sp. is found throughout most of the Early Jurassic, while Z. recessa n. sp. and Z. saezformis n. sp. have more restricted ranges. The Sinemurian Aulacothyris stevensi n. sp. is known from the Hokonui Hills, and the coast north of Marokopa. Two further forms of Aulacothyris are present.

Linguithyris agerorum Manceñido was described from Port Waikato, and is here recorded from New Caledonia. Tegulithyris plencnerae n. sp. is known from the Sinemurian to Toarcian of Kawhia, and Rugithyris hasibuani n. sp. from the Awakino area.

Lobothyris, Aulacothyris and Zeilleria are cosmopolitan and widely distributed. Loboidothyris is also cosmopolitan, but has a Tethyan aspect. Tegulithyris and Rugithyris are Tethyan. Linguithyris is also known from southern Europe, North Africa and western Asia. The highest Early Jurassic brachiopod faunas occur at or just above the Dactylioceras band near Kawhia, which is correlated with the top of the early Toarcian and lies above the Toarcian event in Western Europe.

INTRODUCTION

This paper is intended as a detailed systematic account of the Early Jurassic terebratulide faunas of New Zealand and New Caledonia (Zealandia, sensu Mortimer et al. 2017). It covers the period between the end-Triassic extinction event and the early to mid Toarcian extinctions, and is intended to complement the author’s previous work on Middle and Late Jurassic terebratulides (MacFarlan 2016).

The extinction of several groups of brachiopods and molluscs at or near the end of the Triassic meant that Zealandian Early Jurassic marine faunas are quite different to those of the Triassic. Brachiopods as a whole become less prominent, while rhynchonellides become the dominant group. The spiriferidés are much reduced and the terebratulides, a minor group in the Triassic, become much more significant, in a trend which led to them becoming the major brachiopod group in the Cenozoic.

PREVIOUS WORK

In a paper read to the Wellington Philosophical Society, Hector (1878, p. 537) noted the presence of “the peculiar subgenus of Terebratula represented by the typical “Epithyris elongata” in the Liassic (Bastion) series”. This paper was published only in abstract. The promised substantive paper never appeared, although plates were prepared and were subsequently published by Thomson (1913). Trechmann (1923) described Terebratula (Heinia? 
sp. from the lower slopes of Flag Hill (Ben Bolt), Otagiri Valley, Southland. Marwick (1953) considered this to be Aratauran. MacFarlan and Campbell (2003) described *Zeilleria spiculata* from the latest Triassic and earliest Jurassic, and Manceño (1993a) described *Linguithyris agerorum* from a single Ururoan specimen from Port Waikato.

**METHODS**

This paper is based on material from the collections of the School of Environment, University of Auckland, the Geology Department, University of Otago, and the National Palaeontological Collection at GNS Science. Methods and taxonomic approach are generally those applied in MacFarlan (1992) and MacFarlan (2016).

All suitable specimens were measured (Fig. 1) and catalogued in the relevant specimen catalogue. Specimens with valid length (Ld or Lv) and width data were used in plotting graphs and for statistics. Working photos and camera lucida drawings were taken where required. No serial sections were made as there were too few well-preserved double-valved shell specimens available to justify the destruction of any of them. Attempts at imaging the interiors of some *Dactylioceras* bed specimens using micro-CT were made by Tiffany Plencner of the Geology Department, University of Otago, but were unsuccessful.

**Abbreviations in measurement tables:** dv, dorsal valve; vv, ventral valve; b, both valves; int, internal mould; ext, external mould. Ld, length of dorsal valve (mm); Lv, length of dorsal valve (mm); W, width (mm); H, height (mm); b<, beak angle (°); ant, anterior; post, posterior; F, flattened.

Classification and morphologic terminology follow the revised brachiopod volumes of the Treatise on Invertebrate Paleontology (Kaesler 2000–2007). Authorship for higher taxa, genera and type species also follows Treatise usage unless otherwise stated. Abbreviations used throughout for type species designation are OD (by original designation) and SD (by subsequent designation).

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**Fig. 2 - Jurassic timescale and range chart showing correlations between New Zealand and international stages (adapted from Raine et al. 2015) and ranges of Zealandian terebratulide species. Late Jurassic terebratulide ranges from MacFarlan (2016).**
Locality and collection data: Nearly all localities discussed here are registered in the New Zealand Fossil Record File maintained by the Geoscience Society of New Zealand and GNS Science. Localities are registered by NZMS260 map sheet number and registration number (FR number), with a letter to indicate a recollection (for example R13/f6613A). The associated Fossil Record Electronic Database (FRED) was used extensively to search for collections containing terebratulide material and to obtain locality, stratigraphic and faunal data. New Caledonian collections held in New Zealand are also registered in the Fossil Record File (prefixed NC).

Collections and specimens are catalogued as follows:
Auckland University School of Environment: Collections prefixed AU, brachiopod specimens prefixed B.
Otago University Geology Department: collections under collector’s field number, catalogued specimens prefixed OU.
National Paleontological Collection at GNS Science, Avalon: collections prefixed GS, catalogued specimens prefixed BR.
Natural History Museum, London. Brachiopod specimens are prefixed B.

Locality data is summarised in Appendix.

Correlations: Detailed biostratigraphy in this paper is in terms of the New Zealand stage system as originally proposed by Marwick (1951, 1953) and refined and subdivided by Cooper (2004). Correlations with international stages follow Raine et al. (2015). The stage system and the correlations of key localities and horizons are summarised in Fig. 2.


**Geographic and Stratigraphic Setting**

The material described here comes from the Teremba Terrane on the west coast of New Caledonia (Campbell et al. 1985; Aitchison et al. 1995) and the Kawhia and Southland Synclines, which were deposited within the Murihiku Supergroup, Murihiku Terrane (Campbell et al. 2003; Mortimer et al. 2014). The entire area of continental crust surrounding New Caledonia and New Zealand (Fig. 3) is now seen as forming the largely submerged continent of Zealandia (Mortimer & Campbell 2014; Mortimer et al. 2017).

New Caledonia

Jurassic rocks of the Baie de St.-Vincent Group crop out on the west coast of New Caledonia (Fig. 4), principally in the Moindou area (Campbell & Grant-Mackie 1984), and around Baie de St Vincent. (Paris 1981). The key area is Uitoé Peninsula on the south side of the Baie de St Vincent, where Aratauran to Ururoan rocks are exposed, with ammonites described by Meister et al. (2010) giving an Late Hettangian to early Sinemurian age. Overlying localities are Lower Ururoan with the bivalve *Pseudaucella marshalli*.

Kawhia Syncline

The Kawhia Syncline is exposed from Port Waikato to Awakino. Regional geology is described by Edbrooke (2001, 2005). Significant localities are shown in Fig. 5. Key Early Jurassic sections are:

Port Waikato: (Purser 1961; Waterhouse 1978; Hudson 2003). The Early Jurassic of the Port Waikato area is poorly fossiliferous, and the only terebratulide seen in this study is the sole New Zealand specimen of *Linguithyris agerorum*. This is in contrast to the Middle and Late Jurassic, where it is one of the key areas for brachiopod faunas (MacFarlan 1992, 2016).

Kawhia: The west coast of Te Maika Peninsula (Fig. 5 inset) is the type section for the Aratauran and Ururoan stages (Marwick 1953; Fleming & Keay 1960; Martin 1975; Waterhouse & White 1994) and is a key section for this study. Terebrat-
ulides were examined from several horizons, of which the Upper Ururoan Dactylioceras bed is the most significant.

Akikuni et al. (2010) place the Ota-pirian-Aratauran boundary in the 11-12 m of strata between R15/f184, with a good Otapirian fauna including the brachiopods Clavigera and Mentzelia kawhiana and the bivalve Otapiria dissimilis, and R15/f190 with the earliest Sinemurian ammonites Metophioceras marokopaense and Nevadaphyllites cf. ponnamus. Zhang and Grant-Mackie (2001) identified a boundary zone between the Triassic and Jurassic at about the same level, based on palynology, and Grant-Mackie (2011) discussed the succession of Otapiria in this, and the Awakino Valley. No Hettangian ammonites are known from the Kawhia section, so the Hettangian is very thin or absent (Stevens 2004).

The identification of the ammonite Juraphylites ex gr. liberus from R15/f8819, 400m NE of Otamaehu Point, gives a Pliensbachian age to this part of the section (Stevens 2014) while the ammonite Catacoeloceras grangei from R15/f8005 (Stevens 2008) allows the Dactylioceras band to be correlated with the Crassum Subzone (top of the Early Toarcian).

Raine et al. (2015) define the Upper Ururoan on the lowest occurrence of Catacoeloceras grangei in this section. This means that the diverse molluscan and brachiopod fauna characteristic of the beds above the last appearance of Pseudaucella marshalli are defined as Lower Ururoan, and the Upper Ururoan is essentially restricted to the Dactylioceras bed and the generally unfossiliferous beds above this and below the base of the Temaikan. As Catacoeloceras grangei has not been recorded in other sections this definition can only be applied at Te Maika Peninsula.

In previous subdivisions (MacFarlan 1992; Hudson 2003; Cooper 2004), the Upper Ururoan consisted of the interval between the top of the Pseudaucella marshalli beds and the lowest Temaikan...
fauna. In this paper I use the definition of Hudson (2003, p. 123) “The Upper Ururoan Substage is defined as extending from the last appearance of *Pseudaucella marshalli* to the first appearance of a Temaikan fauna”.

As noted by Hudson (2003), the characteristic Upper Ururoan brachiopod faunas do not extend far above the *Dactylioceras* band. R15/f8006 is best regarded as a number for more poorly localised collections just above or below R15/f8005. The highest locality with Ururoan brachiopods recorded is R15/f8815, 45m stratigraphically above the *Dactylioceras* band, with only *Herangirhynchia herangiensis* of the Ururoan fauna present (Mac-Farlan 1992), together with “*Inoceramus ururoaensis*” Speden (Speden 1970) which is one of the few fossils found in overlying beds.

**Taharoa**: An isolated outcrop on the beach north of Taharoa (R16/f6811) has yielded a diverse Upper Ururoan molluscan and brachiopod fauna (Martin 1975). Stevens (2007) identified *Harpoceras subplanatum* from this locality, indicating an Early Toarcian age, slightly below that of the *Dactylioceras* Band at Ururoa Point.

**Coast north of Marokopa**: The coast north of the Marokopa River has an Otapirian to Aratauran section mapped by Stevens (2012a). The ammo-
nites Metophioceras marokopaense and Nevadaphyllites cf. pounamuus indicate the base of the Sinemurian. The Otapirian-Aratauran boundary is obscured in this section but inferred to be a few metres below (see Stevens, 2012a, fig. 4).

Marokopa: The Otapirian-Aratauran boundary is also exposed south of the Marokopa River at its mouth (MacFarlan 1998). The uppermost Hettangian ammonite Eolytoceras cf. tasekoi in this section (Stevens 2004) indicates that the Hettangian is about 25m thick, and much may be missing. Inland outcrops east of the Manganui Fault are generally weathered, but some terebratulides have been found in the Maropoka Valley and along the Pomarangai Road (MacFarlan 1998).

Awakino: The Awakino Gorge section is Oretian to Ururoan in age (Grant-Mackie 1959; Hudson 2003). The main brachiopod localities are the two quarries beside State Highway 3, which are Upper Ururoan and approximately along-strike. Fault blocks west of the Manganui Fault are of Aratauran age (Campbell and Raine 1989) but terebratulides are rare. In the upper Awakino Valley, north of Mahoenui, a few terebratulides have been collected from tributaries of the Awakino River and from the Ruaroa Valley (Hasibuan 1982; Hudson 2003).

Southland Aratauran and Ururoan strata are found on both flanks of the Southland Syncline but terebratulides are rare except in a few localities (Fig. 6). Regional geology is described by Turnbull and Allibone (2003).

Hokonui Hills: The most complete (but not continuous) Aratauran to Lower Ururoan section is in the Otapiri Valley in the western Hokonui Hills (McKellar 1968, 1977) with diverse brachiopod fau-
Early Jurassic Terebratulide brachiopods from Zealandia

...(text continues here)
Genus *Loboidothyris* Buckman, 1918
Type species - *Terebratula latovalis* Buckman, 1918 OD

1918 *Loboidothyris* – Buckman, p. 112.
2006 *Loboidothyris* Buckman – Lee et al., p. 2082.
2014 *Loboidothyris* Buckman – Alméras et al., p. 18.

*Loboidothyris* is a widespread Jurassic genus, initially described from Britain but since record-
ed from France (Alméras et al. 2014), Germany (Cooper 1983), Spain (García Joral & Goy 1984, 2000), Portugal (Andrade et al. 2016), Italy (Ferrari & Manara 1972), Bulgaria (Tchoumatchenko 1996), Crimea (Kamyshan & Babanova 1973), Peru (Sandy 1994), Argentina (Manceñido & Dagis 1992; Manceñido 2002), Chile (Manceñido 1988), Alberta and California (Crickmay 1933), Greenland (Rosenkrantz 1934), Morocco (Alméras & Faure 2008), the Horn of Africa (Muir-Wood 1935), China (Sun et

![World distribution of terebratulide genera. Data from Fossilworks (downloaded 4 May 2018) and relevant literature. Base maps from Alroy (2013). Online paleogeographic map generator. http://paleodb.org/?a=mapForm. Maps drawn on equirectangular projection for 185 ma, focal co-ordinates -80°, 180°. New Zealand and New Caledonia in the Jurassic were a series of terranes on the subducted margin of Gondwana, and the positions shown on Diagram A are approximate.](image-url)
al. 2017) and possibly Thailand (Alméras 1988). It is also recorded from the Triassic of Peru by Sandy (1994).

Three new species from the Middle and Late Jurassic of New Zealand were provisionally assigned to Loboidothyris by MacFarlan (2016). One further species is described here from the Early Jurassic, again with some qualification as no material suitable for serial sectioning was found. It is found in both the Kawhia and Southland synclines, and New Caledonia.

Lee et al. (2006) give Loboidothyris a time range of Toarcian to Bajocian, and Alméras et al. (2014) of Aalenian to Bajocian. The New Zealand and New Caledonian material has a much longer time range (Aratauran to Upper Heterian, Sinemurian to late Oxfordian).

Peristerothyris Manceñido, 1983, described from the Pliensbachian of Argentina is larger and more strongly folded than New Zealand and New Caledonian specimens of Loboidothyris, but may be related. Jurassic distribution of Loboidothyris is shown in Fig. 8A.

Loboidothyris fordycei n. sp.

Fig. 9, 1-26

2009 Terebratulide sp. indet. A (7n. sp.) - MacFarlan et al. p. 266.


Paratypes: OU 18333 a double-valved internal mould from the same locality and collection. OU 18335, a dorsal valve internal from the same locality, collected by J.D. Campbell 25/4/1981 (JDC 3651).

Derivation of Name: This species is named for Professor Ewan Fordyce, of the Geology Department, University of Otago, custodian of the Otago University specimens described here, for his help and support on many visits to Dunedin.

Material:
New Caledonia
NC/90969 (AU 11221).
Kawhia Syncline

Southland Syncline

A total of 53 specimens were catalogued, of which 44 yielded valid measurements.

Description. Terebratulide of medium size, with subcircular to elongate-elliptical outline. Both valves moderately inflated, the ventral valve generally more so. Anterior commissure shallowly uniplicate to paraplicate.

Ventral valve strongly and evenly convex posteriorly, less convex with broad, blunt poorly-defined central plica anteriorly. Larger specimens have rounded plicae on flanks. Dorsal valve less convex posteriorly, with two relatively narrow-crested rounded plicae separated by broad, shallow sulcus anteriorly. Beak large, inclined to erect, narrowly triangular with bluntly rounded tip. Foramen large, subcircular, permesothyrid, with short pedicle collar. Beak ridges bluntly rounded (Fig. 9.8), deltidial plates probably disjunct. Shell material punctate.

Internal Characters. Dorsal valve with short, broad hinge plate and widely separated sockets. Muscle scars shallowly incised, separated by low, rounded ridges extending for posterior half of valve (Fig. 9.2, 9.11). Muscle scars on ventral valve poorly defined.

Dimensions. Dimensions of types and the New Caledonia specimen, and statistics of Kawhia Syncline and Otapiri specimens are shown in Table 1.

Range and Distribution. Lower Aratauran to Upper Ururoan. The species is common in the Otapiri Gorge Lower Ururoan (E45/f062, E45/f09860) and Heale Ridge (E45/f085) and is represented by single specimens at most other localities.

<table>
<thead>
<tr>
<th>FR no.</th>
<th>specimen</th>
<th>Lv</th>
<th>Lp</th>
<th>W</th>
<th>H</th>
<th>b&lt;</th>
<th>material</th>
<th>notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>E45/f085</td>
<td>OU 46807</td>
<td>24.2</td>
<td>23.1</td>
<td>90</td>
<td>90</td>
<td>-</td>
<td>cv int</td>
<td>Holotype</td>
</tr>
<tr>
<td>E45/f085</td>
<td>OU 18335</td>
<td>18.8</td>
<td>16.2</td>
<td>6</td>
<td>6</td>
<td>-</td>
<td>int</td>
<td>Paratype</td>
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<tr>
<td>E45/f085</td>
<td>OU 18333</td>
<td>22</td>
<td>19.1</td>
<td>6</td>
<td>6</td>
<td>-</td>
<td>int</td>
<td>Paratype</td>
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<tr>
<td>NC/0969</td>
<td>AU B661</td>
<td>21.0</td>
<td>16.4</td>
<td>98</td>
<td>98</td>
<td>-</td>
<td>cv int</td>
<td>Ant margin damaged, slightly distorted</td>
</tr>
<tr>
<td>Kawhia-Marokopa</td>
<td>Mean</td>
<td>25</td>
<td>21</td>
<td>18.5</td>
<td>15.3</td>
<td>90</td>
<td>5 specimens</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>3.35</td>
<td>1.95</td>
<td>1.08</td>
<td>1.5</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Otapiri Valley</td>
<td>Mean</td>
<td>22.8</td>
<td>21</td>
<td>18.4</td>
<td>7.9</td>
<td>87.7</td>
<td>59 specimens</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>4.34</td>
<td>4.09</td>
<td>3.86</td>
<td>1.69</td>
<td>10.14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The oldest is a single valve from the Lower Aratauran on the coast north of Marokopa (R16/f8644), which is highest Hettangian-basal Sinemurian on ammonite evidence (Stevens 2004). The youngest are Upper Ururoan, from R16/f6811 Taharoa, and R15/f8006, Ururoa Point above and below Dactylioceras Band.

Remarks. Most specimens are present as single valves. On the ventral valves of smaller specimens the folding is slight or absent, while larger specimens have broad, bluntly rounded plicae anteriorly (Fig. 9.1a, 9.6, 9.7). Dorsal valves generally show two narrow rounded plicae on the anterior part, with a broad space in between (Fig. 9.16, 9.20).

The late Middle Temaikan Loboidothyris marokopaensis has similar folding in the dorsal valve but much stronger in the ventral, and is generally larger. The Upper Temaikan to Heterian L. grantmackiei is generally larger and does not show the folding, L. awakinoensis is of similar size but less inflated, and also lacks folding, Lobothyris simesi n. sp. has a similar range to L. fordycei, but is rectimarginate, typically much smaller, with a more elliptical outline, much less inflation and a broader, more bluntly rounded beak.

The sole specimen found from New Caledonia (Fig. 9.22) and the few from the Kawhia Syncline (Fig. 9.23-25) are elongate, with a slightly uniplicate anterior commissure, and a shallow poorly defined fold and sulcus, or none. They may represent a separate form. One specimen from The Bastion may belong in this group. The other specimen from The Bastion is a large, slightly inflated, unfolded ventral valve that is questionably included in this species (Fig. 9.26).

Family Lobothyrididae Makridin, 1964
Subfamily Lobothyridinae Makridin, 1964

Lobothyris Buckman, 1918

Type species - Terebratula punctata J. Sowerby, 1813 in 1812-1815, p. 46, OD

1918 Lobothyris Buckman, p. 107.
1983 Lobothyris Buckman - Cooper, p. 103.
1990 Lobothyris Buckman - Ager, p. 11.
2000 Lobothyris Buckman - Lee et al., p. 2103.
2014 Lobothyris Buckman – Alméras et al., p. 71.


Ager (1967) noted that “Thus all over the world, literally from China to Chile (and in most regions exclusively) smooth, rectimarginate forms, probably all referable to Lobothyris” (p. 141). Ager (1990, p. 11) considered Lobothyris to be “a stable rectimarginate stock, which persisted throughout early Jurassic times and spread all over the world”.

In the most recent revision of the genus, Alméras et al. (2014) give a time range for Lobothyris...
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of Hettangian to Aalenian. Other workers (Dagis 1963, 1965; Siblik 1994; Torti & Angiolini 1997) include the Middle to Late Triassic species *Terebratula praepunctata* and other species in the genus. Sandy (1994) records *Lobothyris praepunctata* and a new species *L. triassicus* from the Triassic of Peru, and Blodgett and Clautice (2000) record *L. praepunctata* and *L. sp. cf. L. monstrifer* Dagis from the Norian of Alaska. Jurassic distribution of *Lobothyris* is shown in Fig. 8B.

*Lobothyris* has been recognised as part of the New Zealand Early Jurassic fauna for some time (MacFarlan 1975, 1980, 1992, 1998; Grant-Mackie et al. 2000; Hudson 2003; MacFarlan et al. 2009) but no species has been described until now.

### Lobothyris simesi n. sp.

Fig. 10: 1-22

1923 *Terebratula (Heimia)* sp. - Trechmann, p. 285, pl. XVI figs 4a, 4b. 2009 *Lobothyris* sp. - MacFarlan et al., p. 266.

**Holotype:** BR 2710, a double-valved shelly specimen from R15/B8005, GS 1194, Dactylioceras band (Ururoa Formation), Ururoa Point, Kawhia. Collected by J. Henderson & L.I. Grange 1921.

**Derivation of Name:** This species is named for John Simes, recently retired Curator for GNS Science, for his help with National Paleontological Collection material and the Fossil Record File over many years.

**Material:**


A total of 127 specimens were examined, of which 100 yielded valid measurements.

**Description.** Terebratulide of small to medium size, with elongate-elliptical outline. Both valves slightly to moderately inflated, equally or ventral valve more inflated. Anterior commissure rectilinear or with very shallow uniplication, no fold or sulcus. External smooth or with faint growth lines. Beak suberect to erect, broad, rounded-triangular with bluntly rounded tip. Beak ridges bluntly rounded, poorly developed. Foramen large, circular, permesothyrid, deltidial plates conjunct. A short, poorly developed pedicle collar may be present.

**Internal Characters:** Hingeplate on dorsal valve triangular, cardinal process small, narrow. Paired, slightly incised muscle scars commonly seen on both valves. Those on the dorsal valve are elongate and may be well developed (Fig. 10.7a, 10.9a, 10.16a).

**Dimensions.** Dimensions of the holotype and statistics of specimens from key areas are shown in Table 2.

**Range and Distribution.** Aratauran to Ururoan. Rare in the North Island Aratauran, where specimens (Fig. 10.6) are small, flattened and often poorly preserved, as are all other terebratulides. It is more common in the Upper Ururoan at Kawhia. There are a few scattered records south of Kawhia. In the Otapi Valley, it has not been found in the basal Aratauran of Taylors Stream, but is present in the Taylors Junction and Ben Bolt sections, and in the Lower Ururoan of Conical Hill and Heale Ridge. The species is abundant (30 specimens measured) at E45/9451 (GS 348) on the west side of the Otapi Stream.

**Remarks.** The specimen (NHM B48950) figured by Trechmann (1923) as *Terebratula (Heimia*) sp. from the lower slopes of Flag Hill (Ben Bolt) was re-examined at the Natural History Museum in London. It appears to be typical of Otapi Valley Ururoan members of this species. The long triangular incised muscle scars are clearly shown.

Wanner and Knipscheer (1951) describe *Terebratula? cf. punctata* Sowerby from the Early Jurassic of Seram Island in the Indonesian province of Maluku. Their figures closely resemble *L. simesi*, but three of the four specimens measured are larger than any specimens of *L. simesi* measured in this study. Dr Miguel Manceñido (pers. comm. 11/12/2018) has examined the Seram material and does not believe it should be included in *Lobothyris punctata*.

**Family Tegulithyrididae Muir-Wood, 1965**

*Tegulithyris* Buckman, 1918

Type species - *Terebratula bentleyi* Davidson, 1851 OD

1918 *Tegulithyris* Buckman, p. 123.
1964 *Tegulithyris* Buckman - Malaidin p 264.
1983 *Tegulithyris* Buckman - Cooper, p. 159.
2006 *Tegulithyris* Buckman - Lee et al. p. 2120.
2014 *Tegulithyris* Buckman - Alméras et al. p. 121.
Fig. 10 - Lobothyris simesi n. sp.
1) Holotype BR 2710 (R15/8005) shelly specimen, (a) dorsal, (b) ventral, (c) lateral.
2) AU B574 (R15/8005) shelly specimen, (a) dorsal, (b) ventral, (c) lateral.
3) OU 19480 (R15/8005) shelly specimen, (a) dorsal (b) ventral (c) lateral (d) anterior.
4) OU 45685 (R15/8005) shelly specimen, (a) dorsal (b) ventral (c) anterior (d) lateral.
5) BR 3193 (R15/8006) shelly specimen, (a) dorsal (b) ventral (c) lateral.
6) AU B572 (R15/8697) shelly specimen (a) dorsal (b) ventral (c) lateral (d) anterior.
7) AU B605 (R16/8821) internal mould (a) dorsal (b) ventral.
8) AU B609 (R16/8821) internal mould (a) dorsal view of beak (b) ventral.
9) AU B610 (R16/8821) internal mould (a) dorsal (b) ventral.
10) GS BR 3206 (R17/8007) internal mould (a) dorsal (b) ventral.
11) AU B585 (R17/8566) internal mould (a) dorsal (b) ventral (c) lateral.
12) OU 45681 (E45/8085) internal mould (a) dorsal (b) ventral.
13) OU 17802 (E45/8085) internal mould (a) dorsal (b) ventral (c) lateral (d) anterior.
14) OU 46743 (E45/9568) internal mould (a) dorsal (b) ventral (c) lateral.
15) OU 46746 (E45/9568) internal mould (a) dorsal (b) ventral.
16) OU 46747 (E45/9568) internal mould (a) dorsal (b) ventral.
17) OU 45707 (E45/0379) internal mould (a) dorsal (b) ventral (c) lateral.
18) BR 3256 (E45/9951) shelly specimen, ventral.
19) BR 3228 (E45/9451) internal mould, (a) dorsal (b) ventral (c) lateral.
20) BR 3237 (E45/9451) internal mould with some remaining shell material (a) dorsal (b) lateral.
21) BR 3236 (E45/9451) internal mould (a) dorsal (b) ventral (c) lateral.
22) BR 3276 (E45/9568) partly shelly, shell material degraded, (a) dorsal (b) ventral (c) lateral.
**Tegulithyris** is a strongly folded terebratulide originally described from the Middle Jurassic of Britain. Alméras et al. (2014) recorded the genus from the Late Bajocian to Early Callovian of southern England, Germany, France, the Russian Platform and the Caucasus. Jurassic distribution of *Tegulithyris* is shown in Fig. 8C.

**Tegulithyris? plencnerae** n. sp.

Fig. 11: 1-6.

2009 *Tegulithyris* sp. MacFarlan et al. p. 266


**Derivation of Name:** The new species is named for Tiffany Plencner of the Geology Department, University of Otago, for her determined attempts to make CAT scans of the interior of several *Dactylioceras* Band specimens.

**Material:**

1. **Ururoa Point, Kawhia:** R15/8005 (Dactylioceras) Bed (AU 6425, 9197), R15/8828 (AU 50, 9459), Upper Ururoan.
2. **North of Arataura Point, Kawhia:** R15/8828 (AU 132), R15/8829 (AU 134), Aratauran.

A total of nine specimens were examined, of which five yielded valid measurements.


Internal characters not seen. There was insufficient shelly material for sectioning, so internal details are unknown. The hinge plate appears to be broad.

**Dimensions.** Dimensions of measured specimens are shown in Table 3.

**Range and Distribution.** Upper Aratauran and Ururoan of the Kawhia Coast. The earliest locality, R15/8828 is just north of Arataura Point,

<table>
<thead>
<tr>
<th>FR no.</th>
<th>specimen</th>
<th>Lv</th>
<th>Lp</th>
<th>W</th>
<th>H</th>
<th>b</th>
<th>material</th>
<th>notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>R15/8005 AU B576 10.3 9.4 11 5.2 125</td>
<td>b shelly adhering matrix Holotype.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R15/8005 AU B575 11.1 9.8 10.2 5 112</td>
<td>b shelly ant margin part obscured.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R15/8005 AU B577 9.9 9 9.3 4 116</td>
<td>b shelly adhering matrix.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R15/8828 AU B578 9.7 9.7 2.6</td>
<td>b shelly decorticated, ant and beak damaged.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R15/8829 AU B579 9.1 7.1 9.7</td>
<td>b shelly dv and beak exposed, ant margin damaged.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R15/8866 AU B580 10.3 11.7</td>
<td>dv ext good hinge impression with socket. Finely plicate.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R15/8816 AU B581 9.9 9.3 11.5 3.5 114</td>
<td>b shelly margin damaged.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R15/8816 AU B627 10.3 9.8 11.8 5.8 108</td>
<td>b shelly slightly flattened at anterior.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R15/8816 AU B650 10.6</td>
<td>10.9 112 vv shelly &amp; ext.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

![Table 3 - Dimensions for Tegulithyris? plencnerae.](image-url)
while Stevens (2004) records the Early Sinemurian ammonite *Metophioceras marokopaense* from nearby. The latest locality is R15/18005, the *Dactylioceras* band, Te Maika Peninsula.

**Remarks.** This species is placed with some doubt in *Tegulithyris* on the distinctive folding with concave anterior part to the dorsal valve. The folding is generally shown only on the anterior part and in some specimens is incipient or poorly developed. This species is small for the genus, with a proportionately smaller foramen.

Lee et al. (2006) gives a time range for *Tegulithyris* as Middle Jurassic (Bathonian-Callovian) and Alméras et al. (2014) as Late Bathonian to Early Callovian but the new species is Early Jurassic.

**Family and Subfamily Uncertain**

*Rugithyris* Buckman, 1918

Type species - *Rugithyris subomalogaster* Buckman, 1901

1918  *Rugithyris* Buckman, p. 127.
1983  *Rugithyris* Buckman - Cooper, p. 144.
2006  *Rugithyris* Buckman - Lee et al., p. 2133.
2014  *Rugithyris* Buckman - Alméras et al., p. 127.
Rugithyris hasibuani n. sp.

Fig. 11: 7-15

**Holotype**: AU B615, a double-valved shelly specimen from R17/f227 (AU 7634), tributary of the upper Awakino River. Collected by F. Hasibuan, 7 December 1979.

**Derivation of Name**: This species is named for Dr Fauzie Hasibuan, who as a graduate student of the Geology Department, University of Auckland, collected the upper Awakino River material.

**Material**:

A total of 16 specimens were catalogued, of which eleven yielded valid measurements.

**Description**. Medium-sized terebratulide with subcircular outline. Ventral valve moderately to strongly convex posteriorly, slightly convex anteriorly. Dorsal valve flat to shallowly sulcate posteriorly, flat to slightly convex anteriorly. Anterior commissure rectimarginate. Both valves with ornament of strong, semiregular stepped concentrics, which are generally not seen on the valve interior (Fig. 11.13). Beak broad, erect to incurved, with bluntly rounded tip (Fig. 11.10c). Beak ridges blunt, poorly developed. Foramen moderately large, open, permesothyrid, surrounded by short pedicle collar, with conjunct deltoidal plates. Shell material punctate.

**Internal Characters**. Dorsal valve with straight, narrow hingeplate bearing small cardinal process, sockets small, widely separated. No median septum. Ventral valve without dental plates, Muscle scars not seen on dorsal valve, some indistinct markings on posterior central part of ventral valve may be muscle scars (Fig. 11.8a).

**Dimensions**. Dimensions of the holotype and statistics of specimens from the two main localities are shown in Table 4.

**Range and Distribution**. All the material is to some extent distorted. Most comes from two localities, R17/f227, in a tributary of the upper Awakino River and R17/f8566, the lower of the two quarries in the Awakino Gorge. Both localities are Upper Ururuan (Grant-Mackie 1959; Hudson 2003). A single specimen from the late Otatipian at Marokopa (R16/f8639) lacks the strong semiregular concentrics, and is doubtfully referred to this species. A small flattened specimen from R17/f8556, Manganui Rd Quarry, Awakino Valley (Aratauran) and a similar one from R17/f8567, Upper quarry, Awakino Gorge, are also doubtfully referred to this species.

**Remarks**. No suitable material for sectioning was obtained, so the loop is unknown. It is referred to Rugithyris as it has the close-spaced concentrics and flatly convex dorsal valve characteristic of the genus (Cooper 1983).
Superfamily Dyscolioidea Fischer & Oehlert, 1891
Family Nucleatidae Schuchert, 1929
Linguithyris Buckman, 1918

Type Species - Terebratula bifida Rothpletz, 1886

1918 Linguithyris Buckman, p. 99.
2005 Linguithyris Buckman, 1918 - Artops and Alméras, p. 574.
2006 Linguithyris Buckman, 1918 - Lee, p 2144.

Manceñido (1993a) described Linguithyris aegerorum from a single specimen from the Ururoan of the Port Waikato area, and reviewed the distribution and classification of the Nucleatidae. He records the genus Linguithyris from southern Europe (Spain, southern France, southern Germany, Northern Italy, Austria and the Czech Republic, and North Africa (Tunisia, Algeria and Morocco). It extended further in the Middle Jurassic, reaching Britain, the Balkans, the Ukraine, Bulgaria and Crimea. Manceñido (1993a) also noted that the related Middle and Late Jurassic genus Nucleata has a similar southern European and North African distribution, with a single specimen of Nucleata ex gr. bouei/plandata Zeuscher recorded from the Late Jurassic of the Sula Islands in Indonesia. Jurassic distribution of Linguithyris is shown in Fig. 8D.

Linguithyris is an important member of Jurassic brachiopod faunas of the Mediterranean Province, which occur mainly in carbonate basins, horsts and platforms with reduced terrestrial influence (Vörös 2005; Colás & García Joral 2012).

A few specimens which may belong to Linguithyris or a related form were found from the late Otapirian of Marokopa and Te Maika Peninsula, Kawhia. These require further work.

**Linguithyris aegerorum** Manceñido, 1993a

[Fig. 11: 16-19.]

1993 Linguithyris aegerorum Manceñido 1993a p. 191 fig. 1 a-e.
2009 Linguithyris aegerorum Manceñido - MacFarlan et al. p. 266.

**Holotype**: AU B319 Internal mould and fragment of exterior, from R13/F7048, AU 907, Opua Stream. Collected by K.A. Rodgers and J.A. Grant-Mackie May 1971.

**Material**:
New Caledonia
Uitoé Peninsula: NC/F439 (AU 7339), NC/F468 (AU 7369), NC/F472 (AU 7373).

Kawhia Syncline
Port Waikato: R13/F7048 (AU 907).

A total of four specimens were examined.

**Description.** Terebratulide of medium size, with rounded triangular outline. Dorsal valve moderately convex, ventral valve strongly convex posteriorly and with broad, poorly-defined fold anteriorly. Anterior commissure sulcate, with deep rounded deflection about ¾ of valve width and almost the height of the valve. Exterior of shell smooth, with irregularly-spaced, slightly stepped concentrics. Beak small, triangular, incurved, with rounded tip. Beak ridges moderately strong, rounded. Foramen elliptical, permoestothyrid. On the holotype only the posterior part of the foramen can be seen (Fig. 11.16a), possibly due to damage or affected by the incurved beak. Disjunct deltidial plates and a short pedicle collar are shown on AU B660 (Fig. 11.19a, b). Shell punctate.

**Internal Characters.** Dorsal valve with paired, impressed muscle scars (Fig. 11.16a, 11.19a). No trace of median septum. Hinge plate hidden by incurvature of beak. Small ?gonadal pits on posterior part of ventral valve.

**Dimensions.** Dimensions of the four specimens are shown in Table 5.

**Range and Distribution.** Ururoan, Port Waikato; Arataurau, Uitoé Peninsula, New Caledonia.

**Remarks.** Three specimens of Linguithyris aegerorum were found in a search of New Caledonian Jurassic fossils held in the University of Auckland School of Environment collections. All are from Uitoé Peninsula. No further specimens from New Zealand have been found despite the extensive searches of collections that have been made in the course of this and earlier projects.

<table>
<thead>
<tr>
<th>FR no.</th>
<th>specimen</th>
<th>Lp</th>
<th>W</th>
<th>H</th>
<th>b&lt;</th>
<th>material</th>
<th>notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>R13/F7048</td>
<td>AU B319</td>
<td>25.4</td>
<td>23.7</td>
<td>25.6</td>
<td>14.2</td>
<td>b int. part ext</td>
<td>Holotype</td>
</tr>
<tr>
<td>NC/F439</td>
<td>AU B658</td>
<td>18</td>
<td>17.4</td>
<td>22</td>
<td>14.2</td>
<td>88</td>
<td>b int. distorted. &amp; part ext</td>
</tr>
<tr>
<td>NC/F468</td>
<td>AU B659</td>
<td>35</td>
<td>21.3</td>
<td>21.5</td>
<td>80</td>
<td>b part shelly</td>
<td></td>
</tr>
<tr>
<td>NC/F472</td>
<td>AU B660</td>
<td>16</td>
<td>13.1</td>
<td>18.4</td>
<td>14.6</td>
<td>103</td>
<td>b int. distorted part obscured</td>
</tr>
</tbody>
</table>
R13/f7048 is in an area with few fossil localities, but appears to lie not far above *Pseudancella*. NC/f439 has a non-diagnostic fauna but is close to NC/f440, where Meister et al. (2010) lists the Hettangian *Phylloceras* cf. *psilocomorphum* and *Nevadophyllites* *pounanus*. *Pseudancella marshalli* is also present, which is anomalous. NC/f468 and f472 are below *Pseudancella marshalli* and are Aratauran.

All three New Caledonian specimens are distorted, and the two larger specimens are strongly sulcated anteriorly, although this is accentuated by the distortion. (Fig. 11.17, 11.18).

Suborder **Terebratellidina** Muir-Wood, 1955  
Superfamily **Zeillerioidea** Schuchert, 1929  
Family **Zeilleriidae** Schuchert, 1929  
Subfamily **Zeilleriinae** Schuchert, 1929

Following Manceñido (1993b), Baeza-Carratala & García Joral (2014) and Halamski (2015), the authorship of the Zeillerioidea, Zeilleriidae and Zeilleriinae is accepted as being Schuchert in Schuchert and Levine (1929), rather than Allan (1940).

Genus **Zeilleria** Bayle, 1878  
Type species - *Terebratula cornuta* Sowerby, 1824 in 1823–1825. SD Douvillé, 1879, p. 275

1878 *Zeilleria*, Bayle, pl. 9.  
2015 *Zeilleria* Bayle – Alméras et al., p. 7.

Remarks. Members of the cosmopolitan Late Triassic to Cretaceous genus *Zeilleria* are found throughout the New Zealand Jurassic. The earliest is *Zeilleria spiculata* MacFarlan and Campbell, 2003, which is present in a narrow zone across the Triassic–Jurassic boundary in the Otapiri Valley, Southland, and occurs rarely in the Late Otapirian of the Kawhia Syncline and possibly New Caledonia.

Three further species are described here from the Early Jurassic of New Zealand, while MacFarlan (2016) described three species from the Middle and Late Jurassic of New Zealand and placed a fourth in open nomenclature.

The genus is widespread in the Late Triassic and Jurassic in Europe, North America and Asia, and extends into the Cretaceous in Europe. It is recorded from the Jurassic of Argentina by Manceñido (1991) and Manceñido and Dagis (1992). It is also present in the late Triassic of Papua New Guinea (Skwarko et al. 1976) and New Caledonia (Ernst et al. 2015). A zeilleriid close to *Zeilleria* was recorded from the early Cretaceous of Misool Island, Indonesia by MacFarlan et al. (2011).

Jurassic distribution of *Zeilleria* is shown in Fig. 8E.

**Zeilleria spiculata** MacFarlan & Campbell, 2003  
2003 *Zeilleria spiculata* MacFarlan and Campbell, p 213, Fig. 2-3.  
2009 *Zeilleria spiculata* MacFarlan and Campbell – MacFarlan et al., p. 266.

For description see MacFarlan and Campbell (2003).

Range and Distribution. Late Otapirian to earliest Aratauran. All but two of the specimens examined by MacFarlan and Campbell (2003) were from the Taylors Stream–Otapiri Stream area of the Hokonui Hills, Southland. This area ranges from uppermost Otapirian to the basal to early Hettangian Planorbis Zone (Stevens 2004).

While searching collections for this project, several specimens were found from three localities, F45/f072 (JGGM 131), F45/f092 (JGGM 172) and F45/ f132 (McF C11) in the Rhustra Stream in the Otamita Valley to the east. At F45/f092, *Z. spiculata* occurs with as yet unidentified psiloceratid ammonites. The other two localities lack definitive Otapirian fossils and are inferred to be Aratauran.

The only specimen recorded by MacFarlan and Campbell (2003) from outside the Hokonui Hills was a single specimen from R18/f6562 (AU 326), high in the Otapirian of the Awakino Gorge. Since then, *Z. spiculata* has also been found in the uppermost Otapirian of Marokopa (R16/f6840, GS 10001) and Kawhia (R15/f8834, AU 63). A partial internal mould from New Caledonia (NC/ f1110, AU 13980) may also belong to *Z. spiculata*.

Much smaller specimens from E45/f 9454 (GS 351), E45/f9613 (JDC 1287, McF E39) and E45/f9617 (JDC 1291) in Taylors Stream, occur with normal-sized *Z. spiculata*. These have proportionally larger and sharper beaks and well-developed concentrics. They are interpreted here as juveniles but may be separable.
Zeilleria recessa n. sp.

**Holotype:** OU 45700, a double-valved internal mould and partial external from F45/f8011 (JDC 2479), Diamond Peak Group, Retreat-Croydon Rd, Hokonui Hills. Collected by J.D. Campbell and K.G. Griffin 26/5/1970.

**Paratype:** OU 45693, a ventral valve internal from the same locality and collection.

**Derivation of Name:** Latin for “Retreat”. Most of the material comes from the Retreat-Croydon Road in the Hokonui Hills.

**Material:**
Southland Syncline

Eight specimens were examined, of which 5 yielded valid measurements.


**Internal Characters.** Dorsal valve with broad hingeplate and high wall-like median septum about 1/3 valve length. Muscle scars paired, slightly appressed (Fig. 12.3, 12.8a). Ventral valve with long, fairly close-spaced divergent dental plates delimiting triangular central umbonal cavity from broad lateral cavities. Muscle scars visible behind central umbonal cavity (Fig. 12.8b).

**Dimensions.** Dimensions of measurable specimens are shown in Table 6.

**Range and Distribution.** Most of the described material is from F45/f8011, on north side of Retreat-Croydon Rd. Middle Hettangian ammonites have been found at the same stratigraphic level (Stevens 2004).

A single specimen from F45/f132, Rhutra Stream (OU 19258) has a similar shape but a thicker median septum and hingeplate (Fig. 12.8). It occurs with *Z. spiculata*, and resembles that species in having thicker internal plates.

**Remarks.** All the material from F45/f8011 is flattened and corroded, with heavy limonite staining.

This species is close to *Zeilleria spiculata* but has thinner, more delicate internal plates and an elongate-elliptical outline, whereas *Z. spiculata* is subcircular to transversely elongate. The long closely set dental plates are distinctive.

This species appears stratigraphically above *Z. spiculata* but below the more widely distributed *Z. terezowae* and *Z. saciformis*.

Zeilleria terezowae n. sp.

**Fig. 12: 9 - 27**

**Holotype:** OU 45648, a double-valved shelly specimen from R15/f8005G (McF B2) Dactylioceras bed (Ururoa Formation), Kawhia. Collected by the author, 7 January 1979. Part of the right flank and anterior margin is missing.

**Paratypes:** B568, a double-valved shelly specimen from R15/f8005 (AU 9197). Collected by A.B.S. Clarke, N. Hudson and J.A. Grant-Mackie, 18 January 1981. BR 2712, a double-valved shelly specimen from R15/f8006 (GS 3150) (Ururoa Formation), GS 3150. Collected by J. Henderson, L.I Grange 1921 or later NZGS parties. The specimen has a damaged ventral valve.

**Derivation of name:** this species is named for Marianna Terezow, Collections Manager of GNS Science, who has helped me greatly with the GNS collections in her care.
**Material:**

*Kaibia Syncline*


*Southland Syncline*


A total of 137 specimens were catalogued, of which 110 yielded valid measurements.

**Description.** Terebratulide of small to medium size, with elongate-elliptical to rounded-pentagonal outline, typically with a gently convex to almost straight anterior margin. Valves moderately, evenly and about equally inflated. No fold or sulcus anteriorly. Anterior commissure rectimarginate or with broad, very shallow poorly defined uniplication. Exterior of both valves smooth or with low, irregular growth-lines. The strongest of these are slightly stepped. Beak large, broad, rounded, erect. Foramen elliptical, submesothyrid. Beak ridges strong, narrow, delimiting concave palintropes. Deltidial plates conjunct. Shell strongly, relatively coarsely punctate.

**Internal Characters.** Dorsal valve with median septum about 0.3 to 0.5 of valve length, high, narrow, wall-like. Hinge plate broad, with long sockets extending from either side of shallow rounded septalium. Cardinal process small, narrow. Muscle scars poorly developed (Fig. 12, 21a). Ventral valve with divergent dental cavities delimiting small lateral umbonal cavities, muscle scars on central umbonal cavity.

**Dimensions.** Dimensions of the holotype and paratypes and statistics for key areas are shown in Table 7.

**Range and Distribution.** Aratauran and Ururoa. The most common New Zealand Early Jurassic terebratulide, found throughout the Kawhia and Southland Synclines. It has not been found in New Caledonia. The earliest specimen seen is from E45/f0613 at the base of the Jurassic, where it occurs with the latest Triassic and basal Jurassic Zeilleria spiculata. It is not common in the Aratauran, but is the commonest terebratulide in the Ururoan of Conical Hill, Heale Ridge and Ururoa Point.

**Remarks.** In his 1878 paper, Hector noted “Thus the peculiar sub-genus of Terebratula represented by the typical Epithyris elongata, which has

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Fig. 12 - 1 – 8 Zeilleria recessa n. sp. 1) Holotype OU 45700 (F45/8011) internal mould, (a) dorsal (b) ventral. 2) Paratype OU 45693 (F45/8011) internal mould, ventral. 3) OU 45694 (F45/8011) internal mould, dorsal. 4) OU 45696 (F45/8011) internal mould (a) dorsal (b) ventral. 5) OU 45695 (F45/8011) internal mould (a) dorsal (b) ventral. 6) OU 45697 (F45/8011) internal mould, dorsal. 7) OU 45698 (F45/8011) internal mould (a) dorsal (b) ventral. 8) OU 19258 (F45/8011) internal mould (a) dorsal (b) ventral (c) lateral. 9 – 27 Zeilleria terezowae n. sp. 9) holotype OU 45648 (R15/8005) shelly specimen with part of anterior broken off (a) dorsal (b) ventral (c) lateral (d) posterior. 10) paratype B568 (R15/8005) shelly specimen (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior. 11) paratype BR 2712 (R15/8005) shelly specimen (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior. 12) B564 (R15/8005) shelly specimen (a) dorsal (b) ventral (c) lateral. 13) B563 (R15/8005) shelly specimen (a) dorsal (b) ventral (c) lateral. 14) OU 45653 (R15/029) shelly specimen (a) dorsal (b) ventral (c) lateral. 15) B570 (R15/8697) shelly specimen (a) dorsal (b) ventral (c) lateral. 16) OU 45682 (E45/8085) internal mould (a) dorsal (b) ventral (c) lateral. 17) OU 45673 (E45/8060) internal mould, ventral. 18) OU 45677 (E45/8060) internal mould, dorsal. 19) OU 45660 (E45/8060) internal mould, ventral. 20) OU 45661 (E45/8060) internal mould, ventral. 21) OU 45630 (E45/8060) internal mould (a) dorsal (b) ventral (c) lateral. 22) OU 45669 (E45/8060) internal mould (a) dorsal (b) ventral (c) lateral. 23) OU 45634 (E45/8062) internal mould (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior. 24) OU 45640 (E45/8062) internal mould, ventral. 25) OU 17800 (E45/8085) internal mould (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior. 26) OU 45704 (E45/8060) latex mould of brachial valve and beak exterior. 27) OU 45703 (E45/8060) latex mould of brachial valve and beak exterior. 28 – 38 Zeilleria saciformis n. sp. 28) holotype B565 (R15/8005) shelly specimen (a) dorsal (b) ventral (c) lateral. 29) OU 45846 (R15/8005) shelly specimen, dorsal. 30) OU 45645 (R15/8005) shelly specimen, (a) dorsal (b) ventral. 31) OU 45680 (E45/8085) internal mould, (a) dorsal (b) ventral. 32) OU 45644 (E45/8062) internal mould, dorsal. 33) OU 15293 (E46/0056) internal mould, (a) dorsal (b) ventral (c) latex of exterior of dorsal valve and beak. 34) OU 15294 (E46/0056) internal mould, (a) dorsal (b) ventral. 35) OU 45662 (E46/0056) internal mould, (a) dorsal (b) ventral. 36) OU 45690 (E46/0056) internal mould, (a) dorsal (b) ventral. 37) OU 45689 (E46/0056) (a) external mould of dorsal valve and beak (b) latex of same. 38) OU 46776 (E45/8085) latex of exterior of dorsal valve and beak.
Early Jurassic Terebratulide brachiopods from Zealandia

previously been recorded only from Permian and Carbonaceous strata, is abundant in the Liassic (Bastion) series, and extends downward to the Upper Silurian formation" (p. 537).

The plate in Thomson (1913) is one of those prepared by Sir James Hector but not issued.

*Epithyris* Phillips, 1841 is short-looped and lacks the median septum and dental plates that can
be seen in the plate. GNS specimen BR 1115 is labelled “Probable hypotype of Hector”, and appears to be the original of this figure.

The new species is generally broader and more evenly elliptical than the Tamaikan-Heterian Z. opuatiensis, with much stronger, narrower beak ridges. The anterior margin tends to be straight, whereas in Z. opuatiensis it is narrower and convex.

Aratauran specimens from Kawhia are small, generally flattened, and often have a produced anterior margin (Fig. 12.14, 12.15). Specimens from the Otapiri Gorge and Heale Ridge, western Hokonui Hills, are typically larger and more inflated than those from Ururoa Point (Fig. 12.23).

**Zeilleria sacciformis** n. sp.


**Holotype**: AU B565 a double-valved shelly specimen from R15/8006, AU 592, Ururoa Formation, Ururoa Point. Collected 1943.

**Derivation of Name**: Latin for “sack-shaped” When we first collected this species from Jewitt Road, the late J.D. Campbell likened its shape to a sack of wheat.

**Material**:
- **Kawhia Syncline**: Ururoa Point: R15/8005 (JDC 1151), R15/8006 (AU 592).

A total of 14 specimens were catalogued, of which 10 yielded valid measurements.

**Description**. Small terebratulide with sub-circular outline and less convex to straight anterior margin. Both valves slightly, about evenly inflated. Dorsal valve convex posteriorly, some specimens with two blunt plicae anteriorly, corresponding part of ventral valve slightly convex, without definite plication. Anterior commissure rectimarginate or bicipitate, possibly slightly sulcate. Shell smooth apart from a few semi-regular growth lines which may be slightly stepped. Shell finely and densely punctate. Beak broad, broad, erect with bluntly rounded tip. Foramen small, circular, submesothyrid, with small conjunct deltidial plates. Beak ridges strong, sharply rounded, defining concave palintropes.

**Internal characters**. Dorsal valve with concave hingeplate, small cardinal process, high narrow wall-like median septum which is about 1/3 to ½ valve length. Ventral valve with widely set, slightly divergent dental plates. Central umbonal cavity large, lateral cavities small, triangular. Muscle scars not prominent.

**Dimensions**. Dimensions of measured specimens are shown in Table 8.

**Range and Distribution**. Lower Ururoan (Conical Hill and Heale Ridge, Otapiri) to Upper Ururoan (Dactylioceras Bed, Jewitt Road). At all of these it occurs with Zeilleria terezowae which in all localities other than Jewitt Road is more common.

**Remarks**. The plicae are well-developed only in a few Jewitt Road specimens, (Fig. 12.33, 12.34) which larger numbers may show to be a separable form. Two weathered single valves from F45/8013 in the Waimahaka Valley may also belong here.

This species is smaller and less elongate than Zeilleria terezowae, which is rectimarginate. It is much smaller, and less inflated than the middle to Late Jurassic Z. waiohipaensis, which has a broader, more robust beak and no trace of any plicae.

**Genus Aulacothyris** Douville, 1879

Type species - *Terebratula rostrinato* Sowerby, 1816 in 1815–1818 OD

1879 *Aulacothyris*, Douville, p. 277.
2006 *Aulacothyris* Douville – MacKinnon et al., p. 2167.
Remarks. *Aulacothyris* is a widely distributed Early to Middle Jurassic genus that also has a sporadic Triassic distribution. In the most recent revision, Alméras et al. (2015) state that the genus had three acmes, in the Pliensbachian, Late Bajocian and Early Oxfordian with a total range of ?Anisian, and Early Pliensbachian to Early Oxfordian, They recorded it from Europe, western Asia and North Africa (Tunisia) but also list species from Somalia. Mukherjee (2015, 2017) records *Aulacothyris* from the Callovian of the Kachchh and Jaisalmer Basins of north-west India.

*Aulacothyris* is recorded from the Middle Jurassic of Argentina by Manceñido and Dagis (1992), Manceñido (2002) and Riccardi et al. (2011). Manceñido and Dagis (1992) noted that “For instance, *Aulacothyris* is locally first recorded in the Aratauran (Hettangian?Sinemurian) of New Zealand and the early Pliensbachian of western Europe (Delance 1974), but not until the Aalenian in Argentina (unpublished data) – a pattern that defies a meaningful and straightforward explanation” (p. 329). The New Zealand species they are referring to is described here as *Aulacothyris* sp. A (Miguel Manceñido, pers. comm. 11/12/2018)

MacFarlan (2016) described *A. waikatoensis* from the Temaikan of Opuatia Cliff, Port Waikato, with one Heterian specimen from south of Kawhia.

Jurassic distribution of *Aulacothyris* is shown in Fig. 8F.

The genus is also recorded from the Triassic of Europe (Detre 1993; Siblik 1994; Siblik & Bryda 2005), Laos and Viet Nam (Khuc 2000) and China (Yang & Xu 1966). A single specimen described as *Aulacothyris* sp. is recorded by Drot (1953) from the Late Triassic of New Caledonia. It is less strongly inflated and less sulcate than the new species. Marden et al. (1987) recorded small *Aulacothyris* from an allochthonous limestone block of Oretian (Early Norian) age in melange from the Ruahine Range in the southern North Island. These are much smaller than the species described here. *Aulacothyris* is re-

![Image](https://example.com/image.png)

**Fig. 13: 1-10**

**Holotype:** OU 46753, a double-valved internal mould and partial external, from E45/09676 (JDC 1382), north face of Ben Bolt (Diamond Peak Group). Collected by J.D. Campbell.

**Derivation of Name:** This species is named for Dr Graeme Stevens, Emeritus Scientist at GNS Science, who has helped me for my entire career as a palaeontologist.

**Material:**

- *Kaipara Syncline*
  - North Marokopa coast: R16/18644 (GS 10005).
- *Southland Syncline*
  - North Face Ben Bolt (Otupiri Valley): E45/09676 (JDC 1382), E45/09697 (McF E23).

A total of 17 specimens were catalogued, of which 13 gave valid measurements.

**Description.** Small to medium sized ter-

- **Table 8 - Dimensions for Zeilleria sac-

<table>
<thead>
<tr>
<th>FR No.</th>
<th>Specimen</th>
<th>Lx</th>
<th>Ly</th>
<th>W</th>
<th>H</th>
<th>b</th>
<th>Material</th>
<th>Notes</th>
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<tr>
<td>R15/F0806</td>
<td>AU B565</td>
<td>15.1</td>
<td>13.2</td>
<td>14.3</td>
<td>7.2</td>
<td>94</td>
<td>b shelly</td>
<td>Holotype. good subcircular form. some matrix on ant.</td>
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<td>16.5</td>
<td>14.7</td>
<td>15.6</td>
<td>7.4</td>
<td>107</td>
<td>b shelly</td>
<td>Corroded ext. subcircular.</td>
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<tr>
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<td>18.2</td>
<td>17.7+</td>
<td>10</td>
<td>114</td>
<td>b shelly</td>
<td>R flank damaged. tip of beak damaged</td>
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<td>15.9</td>
<td>17.4</td>
<td>5.6F</td>
<td>103</td>
<td>b int</td>
<td>Subcircular. slightly distorted. flattened. Slight ant folding</td>
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<tr>
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<td>OU 15293</td>
<td>15.5</td>
<td>12.9</td>
<td>14.2</td>
<td>5.8</td>
<td>105</td>
<td>b int</td>
<td>Ext. beak damaged</td>
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<td>13.5</td>
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<td>97</td>
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<td>&amp; part ext</td>
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<td>11.4</td>
<td>9</td>
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<td>105</td>
<td>sv int</td>
<td>Good int</td>
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<tr>
<td>E46/F056</td>
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<td>11.6</td>
<td>10.6</td>
<td>10.3</td>
<td>5.6</td>
<td>107</td>
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<td>&amp; dv &amp; beak ext</td>
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<td>12</td>
<td>10.8</td>
<td>5.5</td>
<td>107</td>
<td>b int</td>
<td>Slightly distorted. beak ant damaged</td>
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<td>E46/F056</td>
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<td>10.9</td>
<td>11.9</td>
<td>5.1</td>
<td>111</td>
<td>dv &amp; beak ext</td>
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<tr>
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<td>12.3</td>
<td>11.2</td>
<td>10.9</td>
<td>3.4</td>
<td>88</td>
<td>b int</td>
<td>&amp; part ext. slightly flattened</td>
</tr>
<tr>
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<td>OU 45691</td>
<td>12.6</td>
<td>12.8</td>
<td>114</td>
<td>sv int</td>
<td>Subcircular, divergent dental plates</td>
<td></td>
<td></td>
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<td>OU 45692</td>
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<td>11.5+</td>
<td>11</td>
<td>sv int</td>
<td>&amp; a. R flank damaged</td>
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<td></td>
</tr>
</tbody>
</table>

**Internal Characters.** Dorsal valve with broad, slightly concave hingeplate, high wall-like median septum about ¼ to 1/3 of valve length. Muscle scars poorly shown. Ventral valve with short, divergent dental plates and large triangular lateral umbonal cavities. Paired, slightly impressed, poorly defined muscle scars near beak (Fig. 13.5 a & b, 13.6 a & b).

**Dimensions.** Dimensions of the holotype and statistics from the two main localities are shown in Table 9.

**Range and Distribution.** All the material comes from three Aratauran localities. In two of these it is associated with late Hettangian to early Sinemurian ammonites (Stevens, 2004).

**Remarks.** The Temaikan-Heterian *A. waika* toensis is of similar size to *A. stevensi* but is more inflated and generally more rounded.

**Aulacothyris sp. A.**

**Description.** Medium-sized terebratulide with elongate-elliptical outline. Moderately inflated, with dorsal valve gently convex posteriorly, nearly flat to slightly sulcate anteriorly. Ventral valve more convex anteriorly, with broad, poorly defined fold anteriorly. Anterior margin strongly convex, rectimarginate to slightly sulcate. Exterior smooth with widely spaced rounded concentrics which are also shown on the valve interior. Beak triangular, suberect with sharply rounded tip, foramen probably of moderate size. Dorsal valve with high narrow median septum, about one-third of valve length. Dental plates in ventral valve long, divergent, muscle scars in both valves poorly defined. Other details not seen.

**Dimensions.** Dimensions of measured specimens are shown in Table 10.

**Range and Distribution.** This description is based on the two specimens from E45/9453 GS 350 (Otapiri Stream below junction). E45/9556 (GS 9556) is nearby and includes *Paracaloceras (Gyrophioceras) lorense*, which is Late Hettangian according to Stevens (2004).

**Remarks.** Specimen BR 3207 from R16/6898 (GS 10009) (Uppermost Otapirian, north Marokopa Coast, is badly distorted but appears to be the same species.

These specimens can be distinguished from the coeval or slightly later (Late Hettangian-early Sinemurian) *A. stevensi* as the latter is smaller and has a rounded-triangular outline and distinctive straight anterior margin. Unless more material can be found it is best not to erect a new species.

The single specimen described by Drot (1953) from the Otapirian of New Caledonia is smaller and proportionally broader.
**Aulacothyris** sp. B

Fig. 13: 14-15.

Two further specimens from the Kawhia Syncline are much smaller than other New Zealand species of *Aulacothyris*. They probably represent a different species.

**Material:**
Kawhia Syncline

**Description.** Small terebratulide with subcircular outline, moderately inflated with ventral valve more inflated than dorsal. Dorsal valve convex posteriorly, with shallow, distinct rounded sulcus anteriorly. Ventral valve moderately and evenly inflated, with no distinct fold. Anterior commissure broadly sulcate. Exterior of both valves smooth, with occasional low rounded concentrics anteriorly. Beak rounded, damaged in sole double-valved specimen. Shell densely punctate. Dorsal valve interior (B584, Fig. 13.14a) with high wall-like median septum about 0.4 valve length. Other details not seen.

**Dimensions.** Dimensions of measured specimens are shown in Table 11.

**Range and Distribution.** Only two specimens have been seen, which probably belong to the
same species. B584 is from R16/f8934, Marokopa (mapped as Aratauran by MacFarlan (1975), while BR 3200 is from R15/f8006, Ururoa Point (Upper Ururoan).

Remarks. These two specimens are smaller than any other New Zealand species of *Aulacothyris*. The material is insufficient for further comment.

**Discussion**

**Faunal Changes at the Triassic-Jurassic Boundary**

The end-Triassic extinction event is regarded as a major, worldwide event (Hallam 1981; Kiessling et al. 2007; Damborenea et al. 2017). In Zealandia, the distinctive Maorian fauna epitomised by *Clavigera, Rastelligena* and the trigoniid *Maoritrigonia* disappears and is replaced by more cosmopolitan faunas (Campbell 1991; Fleming 1987; MacFarlan 1992; MacFarlan & Campbell 2003).

The changes began in the Upper Otapirian, with the appearance of *Mentzelia kawhiana* and *Otapiria*. *Zelleria spiculata* appears in the uppermost Otapirian (MacFarlan & Campbell 2003) and spans the boundary, as do the rhychonellides *Vincentirhynchia pomeyroli* and *Sakawairhynchia mokauensis*. *Sakawairhynchia marokopana* is found throughout the Otpirian, and extends into the Lower Aratauran. *Mentzelia kawhiana* is replaced by the Aratauran *Mentzelia ongleyi* (Wright and Campbell 1990). *Aulacothyris* sp. A may also span the boundary.

Otapirian terebratulides are poorly known, and need a detailed systematic survey.

**Faunal Changes in the Toarcian**

The brachiopod faunas of the later part of the Ururoan in Zealandia are distinctive, but most species first appear in the Upper Aratauran or earlier in the Ururoan, within the range-zone of *Pseuduncella marshalli*. The most diverse brachiopod faunas are those from Ururoa Point, especially the *Dactylioceras* band, with four species of rhychonellide (MacFarlan 1992), five species of terebratulide, and at least two species of spiriferide. This fauna does not reach much higher than the *Dactylioceras* band (Hudson 2003).

Ammonites in the *Dactylioceras* band are correlated with the Crassum Subzone of the Bifrons Zone at the top of the Early Toarcian (Stevens 2008). This is considerably higher than the anoxic horizons which are associated with the major extinctions of brachiopods at the Early Toarcian Tenuicostatum-Serpentium Zone boundary in Western Europe (García Joral et al. 2011) but which have a world-wide extent (Gröcke et al. 2011; Al-Suwaidi et al. 2016). The rhychonellides and terebratulides recovered but the spiriferides and koninckinids became extinct (Vörös et al. 2016).

Analysis of changes in ammonite faunas, especially those from high Northern Hemisph eric latitudes, indicates multiple peaks and troughs in extinction rates, suggesting that there were several phases of extinction in the Pliensbachian and Toarcian (O’Dogherty et al. 2000; Dera et al. 2010), with a major diversity peak followed by a sharp decline in the late Bifrons Zone (Caruthers et al. 2003, 2014). A peak and decline at about the same level was shown by Ricardi (2008) from Argentina. In Zealandia the global effects may have been exacerbated by the widespread shallowing that occurred in the Temaikan. As discussed by Hudson (1999, 2003), the break is facies controlled, with non-marine beds at Kawhia, and coarse-grained beds which may represent environments unsuitable for brachiopods elsewhere.

The overlying Temaikan terebratulide and rhychonellide faunas are entirely different at the species level, and the spiriferides become extinct. The terebratulides remain a major group of brachiopods in the Late Jurassic, and by the Cenozoic are much the larger group. There is a general increase in brachiopod size from Early to Middle Jurassic, which will be examined in future work.

The base of the overlying Temaikan stage was defined on the appearance of the belemnites *Belemnopsis mackayi* or *Belemnopsis deborahae* (Hudson 2003; Cooper 2004; Rainie et al. 2015). With the taxonomic revision of Challinor and Hudson (2017), these are now termed *Eobelemnopsis robustus* and *Eobelem-
Early Jurassic Terebratulide brachiopods from Zealandia

Lobothyris. Raine et al. (2015) and Challinor and Hudson (2017) correlate the base of the Temaikan with the Late Toarcian (Fig. 2). Lower Teraimaik brachiopods are restricted to rare Aucklandirhynchia aucklandica (Hudson, 1999), and a more diverse rhynchoellid – terebratulide fauna does not appear until the Middle Temaikan (MacFarlan 2016).

New Caledonia

Terebratulides are not common in the New Caledonian Early Jurassic. Most of the material comes from the Aratauran – Ururoan of Uitoé Peninsula, where three Aratauran localities yielded Linguithyris aegerorum in contrast to the single specimen known from New Zealand. One specimen of Loboidothyris fordycei was found from the Ururoan NC/969, west of Moindou (Wiley 1996). Other material is indeterminate.

No determinable Middle Jurassic terebratulides were found in New Caledonian middle Jurassic localities during work for MacFarlan (2016), but since then a few specimens have been noted from within the Teraimaik material is indeterminate. Loboidothyris fordycei was found from the Ururoan NC/969, west of Moindou (Wiley 1996). Other material is indeterminate.

Affinities of Zealandian Early Jurassic terebratulide faunas

The two genera which are the most significant in the Early Jurassic, Lobothyris and Zeilleria, are cosmopolitan and widely distributed throughout the world (Fig. 8), as is Aulacothyris. Loboidothyris is also cosmopolitan but has a Tethyan aspect. Teguithyris and Rugithyris are Tethyan but less widely distributed. Linguithyris is also found in southern Europe, North Africa and western Asia, with one specimen known from the Late Jurassic of Indonesia. The fauna as a whole can therefore be described as cosmopolitan with a Tethyan aspect. This is in contrast to the strongly endemic Late Triassic brachiopod faunas of the Maorian province (Campbell 1985, 1991; MacFarlan 1992) that precede it, and the more overtly Tethyan brachiopod faunas of the Middle and Late Jurassic (MacFarlan 2016).

Bivalves and rhynchoellid and spiriferide brachiopods in the early Jurassic of Zealandia show strong affinities with those of Argentina and Chile (Damborena & Manceñido 1991), but a similar affinity is not obvious in terebratulide faunas.

Acknowledgements: To Neville Hudson, School of Earth Sciences, University of Auckland, Ewan Fordyce and Sophie White, Geology Department, University of Otago, John Simes and Mariana Terezo, National Paleontology Collection, GNS Science, Lower Hutt for their assistance with access to collections and loan specimens in their care. To Tiffany Plejner, Geology Department, University of Otago, for attempting Cat scanning of specimen interiors. To Daphne Lee, Geology Department, University of Otago, and Hamish Campbell, GNS Science, for reviewing early versions of this manuscript, and for advice and encouragement throughout. To Zoe Hughes, Natural History Museum, London for her help with the Trechmann Collection. To Graeme Stevens for his help with ammonite faunas and zonation. To Jack Grant-Mackie for support and advice at all stages of this project. To the participants in the 8th International Brachiopod Congress, Milan and the IGCP Symposium 632, Napier, for discussions on this project from different perspectives. To Dr Fernando García Joral and the leaders and participants in the 8th IBC field trip for showing me and discussing the Spanish Early Jurassic. To Miguel Manceñido and Susana Damborena for very helpful discussions during their visit to New Plymouth. To the reviewers and editors for improving the final manuscript.

References


Delance J.H. (1974) - Zeillerides du Lias d’Europe Occiden-
Early Jurassic Terebratulide brachiopods from Zealandia


2082-2135. Geological Society of America and Paleontological Institute, Boulder, Colorado and Lawrence, Kansas.


### APPENDIX - Locality data

#### New Caledonia

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<th>FR Number</th>
<th>NCTM Easting</th>
<th>NCTM Northing</th>
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<th>Collection number</th>
<th>Stage</th>
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<td>616020</td>
<td>7558320</td>
<td>Uitoé Peninsula</td>
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**Kawhia Syncline**

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<td>2646700</td>
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<td>Coast north of Marokopa</td>
<td>AU 907</td>
<td>Hu</td>
<td>J.A. Grant-Mackie, KA Rodgers &amp; student</td>
<td>300m N of Tauhua Stream mouth, coast north of Marokopa River</td>
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<td>R15/0006</td>
<td>2664800</td>
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<td>Ururoa Point close to Dactylioceras band</td>
<td>AU 959</td>
<td>Hu</td>
<td>W. Barter, W. Gardner</td>
<td>1943</td>
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<tr>
<td>R15/0078</td>
<td>2664605</td>
<td>6342900</td>
<td>Hole in the Wall, Ururoa Point</td>
<td>AU 959</td>
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<td>1955</td>
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<td>R15/0179</td>
<td>2664750</td>
<td>6342750</td>
<td>Ururoa Point, Hole in the Wall S side</td>
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<td>Hu</td>
<td>W. Hudson May 10, 1982</td>
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<td>R15/0575</td>
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<td>Ururoa Point</td>
<td>JDC 1150</td>
<td>Hu</td>
<td>J.D. Campbell, D.S. Coombs</td>
<td>1954</td>
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<td>R15/0588</td>
<td>2663383</td>
<td>6341746</td>
<td>200m N of Antaura Point</td>
<td>JDC 1167</td>
<td>Hu</td>
<td>J.D. Campbell, D.S. Coombs</td>
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<td>R15/0527</td>
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<td>240m S of Otamaehu Point</td>
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<td>R15/0816</td>
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<td>6341566</td>
<td>320m NE of Antaura Point</td>
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<td>R15/0834</td>
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<td>6341256</td>
<td>140m SSW of South wall of Antaura Point</td>
<td>AU 63</td>
<td>Bo</td>
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<td>R15/0838</td>
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<td>6341167</td>
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<td>R15/0875</td>
<td>2662620</td>
<td>6342270</td>
<td>Shore platform at head of Waitupu Inlet, Kawhia Harbour</td>
<td>AU 9217</td>
<td>Hu</td>
<td>W. Hudson</td>
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<td>R16/0149</td>
<td>2660200</td>
<td>6342470</td>
<td>500m N of Tauhua Stream mouth, coast north of Marokopa River</td>
<td>AU 8539</td>
<td>Hu</td>
<td>J.G. Begg et al.</td>
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*Early Jurassic Terebratulide brachiopods from Zealandia*
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<td>R16/B640</td>
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<td>6324734</td>
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<td>R16/B648</td>
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<td>6323361</td>
<td>Coastal cliffs 110m north-west of mouth of Tuhua Stream</td>
<td>GS 10035</td>
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<td>R16/B649</td>
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<td>R16/B704</td>
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<td>6323496</td>
<td>base of cliff 1.3 km north of mouth of Tuhua Stream</td>
<td>GS 11445</td>
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<td>J.W. Keyses, G.R. Stevens</td>
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<td>R16/B311</td>
<td>2664838</td>
<td>6315548</td>
<td>Pumarangi Rd, 8m upstream through lowest hairpin in 20m above 5m waterfall in main stream</td>
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<td>6283197</td>
<td>Awakino Gorge 1.5 km north of Bexley Creek</td>
<td>GS 911</td>
<td>Hu</td>
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<td>R1/T237</td>
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<td>6284400</td>
<td>Quarry, Awakino Gorge</td>
<td>AU 9408</td>
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<td>6284230</td>
<td>Quarry in Manganiu Rd. near foot of first hill north of Awakino</td>
<td>MdF F9</td>
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<td>6283800</td>
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Southland Syncline

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<td>J.J. Raine, H.J. Campbell, 8/6/1981</td>
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<td>2158100</td>
<td>5454099</td>
<td>Hill to east of Otapiri Gorge</td>
<td>MF C10</td>
<td>Hu</td>
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<td>Zeilleria terezowae, Zeilleria sacciformis</td>
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<td>E45/B0070</td>
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<td>South branch Taylors Stream</td>
<td>MF E26</td>
<td>Ha</td>
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<td>E45/B1115</td>
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<td>Otapiri Stream 250-300m below Taylors Stream mouth</td>
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<td>E45/B2279</td>
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<td>E45/P615</td>
<td>2161619</td>
<td>5459208</td>
<td>Quarry near Taylors Stream</td>
<td>IDC 1289</td>
<td>Ha</td>
<td>J.D. Campbell I.C. McKellar</td>
<td>26/1/1955</td>
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<td>E45/P617</td>
<td>2162072</td>
<td>5459505</td>
<td>South bank Taylors Stream</td>
<td>IDC 1291</td>
<td>Ha</td>
<td>J.D. Campbell I.C. McKellar</td>
<td>26/1/1955</td>
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<td>E45/P618</td>
<td>2158704</td>
<td>5461366</td>
<td>Road cutting 100m N of Taylors Crossing bridge</td>
<td>IDC 1293</td>
<td>Bo</td>
<td>J.D. Campbell I.C. McKellar</td>
<td>27/1/1955</td>
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<td>E45/P629</td>
<td>2152321</td>
<td>5457968</td>
<td>Ridge Crest, Trig NN (Oreti Valley)</td>
<td>GS 6371</td>
<td>Ha</td>
<td>J.C. McKellar, P.M. Chandler</td>
<td>2/1955</td>
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<td>E45/P662</td>
<td>2158802</td>
<td>5455657</td>
<td>southwest slopes Ben Bolt.</td>
<td>GS 6604</td>
<td>Hu</td>
<td>J.C. McKellar</td>
<td>Lobathyris fordycei</td>
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<tr>
<td>E45/P676</td>
<td>2160118</td>
<td>5458832</td>
<td>north face Ben Bolt.</td>
<td>IDC 1382</td>
<td>Ha</td>
<td>J.D. Campbell (various), J.D. Campbell, A. Grebneff, M.O. Manceñido, S.E. Damborenea</td>
<td>1/3/1990</td>
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<td>E45/P697</td>
<td>2159800</td>
<td>5458599</td>
<td>north-west face Ben Bolt</td>
<td>McF E23</td>
<td>Ha</td>
<td>D.A.B. MacFarlan, J.G.G. Morton</td>
<td>20/1/1980</td>
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<td>E45/P711</td>
<td>2154618</td>
<td>5462530</td>
<td>north-west face The Bastion</td>
<td>GS 6748</td>
<td>Ha</td>
<td>Chandler, P.M., McKellar, I.C.</td>
<td>20/8/1956</td>
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<td>E45/P9860</td>
<td>2158321</td>
<td>5443639</td>
<td>north-west of Conical Hill, Otapiri Valley</td>
<td>IDC 1837</td>
<td>Hu (f)</td>
<td>J.D. Campbell (various)</td>
<td>Lobathyris fordycei, Zeilleria terezowae</td>
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<td>E45/P9895</td>
<td>2159759</td>
<td>5461156</td>
<td>outcrop and scree, Taylors Stream N of Warwick Downs homestead</td>
<td>IDC 1976</td>
<td>Ha</td>
<td>J.D. Campbell</td>
<td>15/9/1963</td>
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<td>E45/P9910</td>
<td>2160589</td>
<td>5460713</td>
<td>200m N of north-west branch Taylors Stream</td>
<td>IDC 2095</td>
<td>Bo</td>
<td>J.D. Campbell, B.R. Paterson</td>
<td>18/6/1965</td>
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<td>E45/P9911</td>
<td>2160680</td>
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<td>Taylors Stream</td>
<td>IDC 2096</td>
<td>Bo</td>
<td>J.D. Campbell, BRP</td>
<td>18/6/1965</td>
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<td>E46/B63</td>
<td>2165650</td>
<td>5439599</td>
<td>Jewitt Road, north side at corner</td>
<td>IDC 4661</td>
<td>Hu (u)</td>
<td>J.D. Campbell AG</td>
<td>25/5/1998</td>
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<td>E46/I7538</td>
<td>2165559</td>
<td>5438113</td>
<td>1.2 km up tributary to Makarewa River</td>
<td>GS 5598</td>
<td>Ha</td>
<td>GG Cossem</td>
<td>1/5/1951</td>
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<td>E45/I072</td>
<td>2173250</td>
<td>5456049</td>
<td>Quarry on south side of road near Rhustra stream crossing</td>
<td>IDGM 131</td>
<td>Hu</td>
<td>J.G.G. Morton</td>
<td>15/2/1979</td>
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<td>E45/I083</td>
<td>2175590</td>
<td>5455649</td>
<td>Tributary of Peel Stream</td>
<td>IDGM 157</td>
<td>Ha</td>
<td>J.G.G. Morton</td>
<td>18/2/1979</td>
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<td>E45/I092</td>
<td>2173300</td>
<td>5456059</td>
<td>Outcrop between Rhustra Quarry and road</td>
<td>IDGM 172</td>
<td>Bo-Ha</td>
<td>J.G.G. Morton</td>
<td>23/6/1979</td>
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<td>E45/I132</td>
<td>2173300</td>
<td>5456299</td>
<td>Otamita Valley Road, high roadcut 50m W of Rhustra Stream culvert</td>
<td>McF C11</td>
<td>Ha</td>
<td>D.A.B. MacFarlan</td>
<td>18/3/1979</td>
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<td>E45/I011</td>
<td>2183278</td>
<td>5453880</td>
<td>On NE side of Retreat-Croydon Road at bulldozed face</td>
<td>IDC 2479</td>
<td>Ha</td>
<td>J.D. Campbell K.G. Griffin</td>
<td>26/3/1970</td>
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<td>E45/I073</td>
<td>2176398</td>
<td>5455408</td>
<td>Otamita Valley 30m south of Otamata-Lara road</td>
<td>GS 7624</td>
<td>Ha</td>
<td>J.C. McKellar</td>
<td>1954</td>
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